ISSN (Print) : 2320 – 3765
ISSN (Online): 2278 – 8875

International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering

(An ISO 3297: 2007 Certified Organization)

Vol. 4, Issue 6, June 2015

Power Quality Improvement Wind/PV Hybrid System by using Facts Device

Prachi P. Chintawar[1], Prof. M. R. Bachawad[2]

PG Student [EPS], Dept. of EE, Government College of Engg, Aurangabad, Maharashtra, India[1]

Assistant Professor, Dept. of EE, Government College of Engg, Aurangabad, Maharashtra, India[2]

ABSTRACT:In recent year, for electrical energy production renewable energy played more and more important role in system. Two or more different system use for making energy called hybrid system. In this paper hybrid system is a combination of wind energy and solar PV array with showing hybrid system is more important than indivisiual one. The proposed DC-DC boost converters are used for both sources i.e. wind and PV having less number of switches. Using PI controller, varying DC output are converted into constant. Hybrid system not only improve the power but also cost of the system. This paper proposed that the power quality improvement of hybrid system using D-STATCOM use in the system. To remove the harmonics in the current and give constant power supply. This proposed hybrid system simulates on MATLAB software.

KEYWORDS: DC-DC boost converter, D-STATCOM, PV array, SPWM inverter, Wind energy

I.INTRODUCTION

Day increasing the rate of fossil fuel is making the supply demand of electricity but impossible in remote areas. Renewable energy is the best option for developed countries to produced electric power in location where expensive to use the conventional grid supplies. Most of the researchers are research how to utilize energy and how to conserve energy in better way. For electric power generation Renewable hybrid system utilized. Separately any renewable also generation Electric Power but hybrid system give constant Power to load. Year by Year demand of electricity rapidly increasing. But Energy generation plant not provide that much of energy, so there will be increasing load shading Problems. Because of this reason Renewable energy sources have become import for these days. In number of application multiple renewable energy system are required to connect load or grid [1]. For good power management multiport DC-DC converters are proposed to hybrid application. To generate variable DC into fixed DC the DC-DC converter is use. There are many renewable hybrid energy system like PV-Hydro, PV-Fuel cell, PV-Biomass, Wind-PV etc. Pollution free and inexhaustible energy are present on earth that is the solar energy [4]. PV panel can extract the solar irradiance and produced large amount of power. Wind energy is the form of kinetic energy and this energy is convert into whatever customer demands. Windmill is use in many ruler area for water pumping. Wind turbines gives mechanical power and then with the help of generator gives electric power. In this paper, Wind-PV hybrid renewable energy connected to load for proper power management with uses only one controllable switch. Generation power from wind is AC that converted first into DC then applied DC-DC Boost converter. Similarly from PV is DC that directly applied to new converter. This Multiport DC-DC boost converter are control by PI/PID Controller. This PV-Wind Hybrid system provides electricity power to private house, firm house, apartment, street light, etc. electrical power depending on the need of where the site is use. Aim of my project to connect the wind-PV to dc link capacitor and fulfil all the needs from customer. The settling time be reduced than the indivisiual one with increasing output.

The SPWM inverter is connect to convert the DC sources into AC for nonlinear AC load. The FACTS devices is connect parallel between inverter and load [6]. To improve power quality reduces harmonics in supply and produces the same power at all time. The paper Modelling and simulation of the system in MATLAB Simulink. In Section 2 gives details about the system summary. Section 3 provide details of the system modelling components. Section 4 gives MATLAB overall simulation and discuss the results. Conclusion of the proposed system in section 5.

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II.PROPOSED SYSTEM SUMMARY

Because variable power produced from WIND-PV hybrid system, the output of inverter is variable. Harmonics are present in the system and inverting voltage is variable. Then implement Distribution side means load side is D-STATCOM (distributed static compensator) to reduced harmonics compensation and gives the voltage stability all time. Shunt connected reactive power compensation device that is D-STATCOM to capable generating and absorbing reactive power. The AC power is obtain from inverter and produced to non-linear load with having fluctuation. To reduce that fluctuation, D-STATCOM is very important to improvement of power quality of supply.

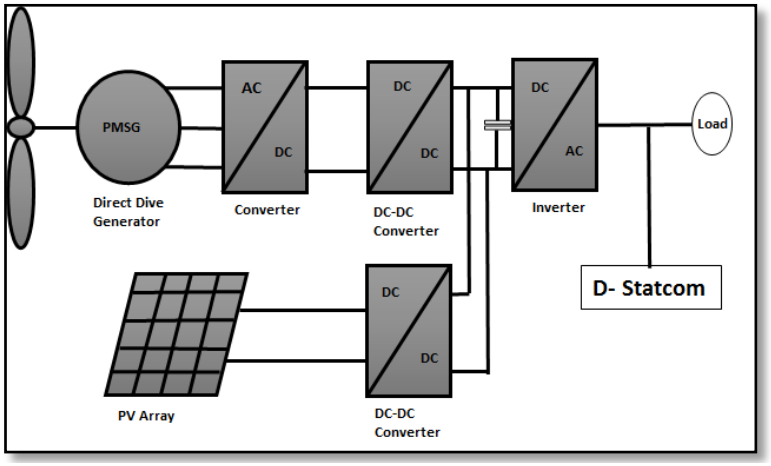

Fig. 1 Hybrid system model with FACTS device

III.SYSTEM COMPONENT MODELLING

A. WIND SYSTEM

One of the quickly growing electricity in the world is wind generation. Wind is the form of kinetic energy that converted to first mechanical with the help of turbine. For generation of electricity from wind, system having PMSG, inverter, Rectifier. In the system wind turbine capture the energy from wind, and generator convert that mechanical energy into electrical. With the help of power electronics apparatus converts the power from low to high quality and it control the rotor generatorspeed. Power generated by wind turbine-

$$P = \frac{1}{2}\varrho A C_p(\lambda) V^3 \qquad (1)$$

ϱ=Air density
A= Area of swept out by turbine
V=wind speed
$Cp(\lambda)$=power coefficient
λ= tip speed ratio

Maximum value of power coefficient theoretically is 0.59. It is depend on two variable λ and pitch angle.
Tip speed ratio is given by

$$\lambda = \frac{Rn\pi}{30V} \qquad (2)$$

n=turbine rotor speed in R/min

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The power coefficient of the wind turbine-

$$C_p(\lambda) = C_1\left(\frac{C_2}{\lambda_1} - C_3\beta - C_4\right)e^{-C_5/\lambda_i} + C_6\lambda \quad (3)$$

$$\frac{1}{\lambda_i} = \left[\frac{1}{\lambda + 0.089} - \frac{0.035}{\beta^2 + 1}\right]$$

When β= 0 that is the pitch angle then $\lambda = 6.325C_p$ is maximum value

In this project use for generating power from wind use PMSG generator that is permanent magnet synchronous generator. One of the main advantage is that it does not need reactive magnetizing current. In synchronous generator, magnetic field is created by using permanent magnet, or conventional field winding. It can used with any gear box for direct drive application [3]. Application of PMSG in wind turbine Because of their property of self-excitation which allow an operation of high power and high-efficiency. Permanent magnet use typically low power generated application and having low-cost. DC-DC boost converter are used to converter the low power to high.

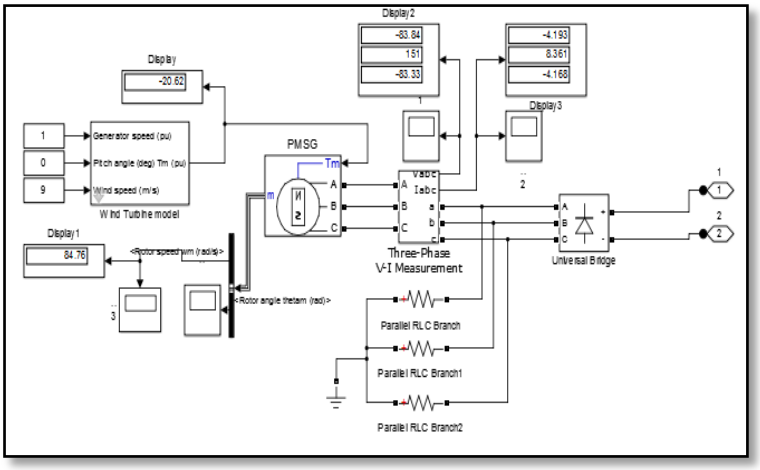

Fig. 2 Matlab wind model

B. PV SOLAR SYSTEM

The solar panel is convert solar energy into electrical energy with DC-DC converter to step up the voltage of the solar energy. In general Current source are connect with parallel to the diode can be represented as a photovoltaic cell [2]. The equivalent circuit also combination of series resistance and shunt resistance represented by Rsh whose value is large and Rs is small. Photovoltaic cell is the semiconductor device that absorb the energy and convert energy of light into electricity by the effect of solar radiation and temperature. The equivalent circuit shown below-

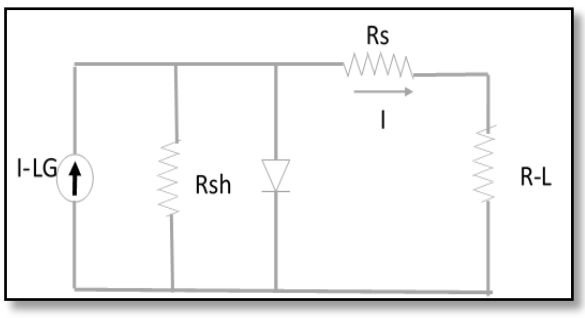

Fig. 3 Equivalent circuit of PV model

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ISSN (Online): 2278 – 8875

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The corresponding characteristic of the solar cell is below:

$$I = I_{LG} - I_D - I_{Rsh} \qquad (4)$$

$$\mathrm{I} = \mathrm{I_{LG}} - \mathrm{I_{OS}}\left\{exp\left[\frac{\mathrm{q}}{\mathrm{AKT}}(\mathrm{V} + \mathrm{IR_s})\right] - 1\right\} - \frac{(\mathrm{V}+\mathrm{IR_S})}{\mathrm{R_{sh}}} \qquad (5)$$

I: Cell output current. (A)
V: cell output voltage
I_{LG}: Photon current. (A)
I_{os}: PV cell's reverse saturation current. (A)
K: Boltzmann's constant. $(1.38 * 10 - 23$ J/°K)
q: Electron charge. $(1.6 * 10 - 19$ C)
a, b: Ideality constant, between 1 and 2
R_{sh}: PV cell parallel resistance. (Ω)
R_s: PV cell series resistance. (Ω)

Under short circuit and open circuit condition mathematical model of PV cell has been created

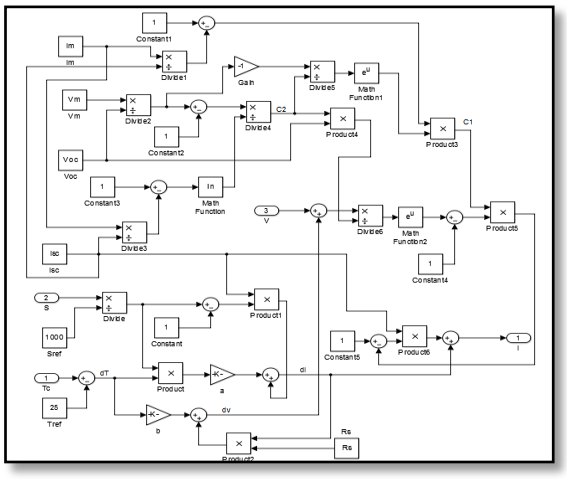

Fig. 4 Mathematical PV model

C. DC-DC BOOST CONVERTER

DC-DC converter are operate as a Boost, Buck and Buck-Boost in different way with different voltage output. There is one MOSFET/IGBT used for ON-OFF control. ON-OFF control is depend on the switching circuit.

1. Open loop system
2. Closed loop system

In this paper there is closed loop circuit is use. In close loop circuit output voltage is compared with reference voltage. DC-DC boost converter not only increase the output but also give constant output than input. Because wind and PV gives a variable output and boost converter gives the constant output than input.

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(An ISO 3297: 2007 Certified Organization)

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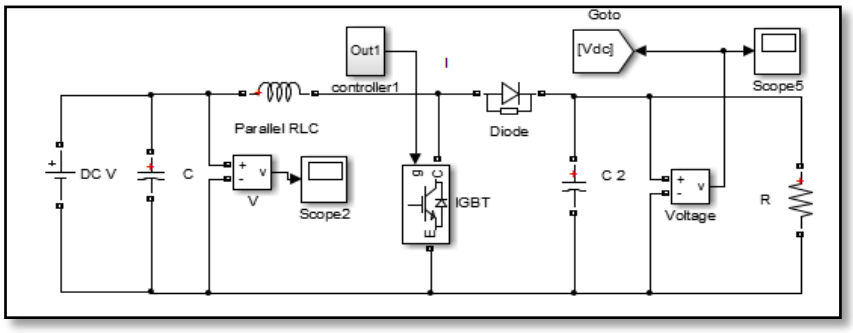

Fig. 5 DC-DC Boost converter

D. PI CONTROLLER

Produced rectified voltage maintain constant at all time with DC-DC boost converter. The boost converter control by PI controller. In close loop controller the output value is compared with reference value and error calculate. These error goes to PI controller and give the constant output. These constant value compared with repeating sequence to generate gate pulse. Gate pulse give the duty cycle of MOSFET/IGBT to control the output.PI controller does not give fast response. But the good result is given than PID because there's one addition function derivatives [1].

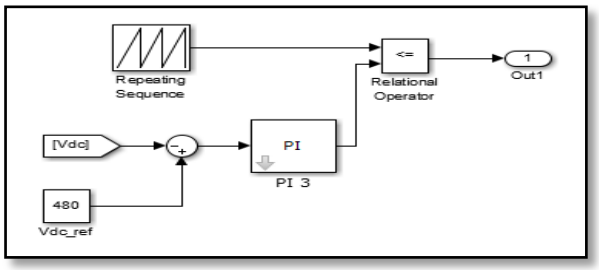

Fig. 6 PI controller

E. SPWM INVERTER

Low frequency sinusoidal pulse compare with high frequency repeating sequence known as a carrier signals. Comparison between the carriers based signal or repeating sequence and sinusoidal signal known as SPWM method i.e. sinusoidal pulse width Modulation. In this method controlled AC output voltage with adjusting the ON-OFF period by giving the fixed DC to inverter. In SPWM i.e. sinusoidal pulse width modulation gives the output AC $V_{max} = \frac{V_{dc}}{2}$. To understand and to implement in software and hardware SPWM techniques is easiest modulation [5].

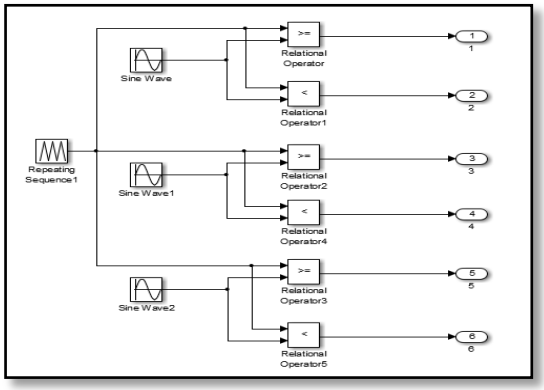

Fig. 7 ON-OFF signals generate for SPWM

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ISSN (Online): 2278 – 8875

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F. D-STATCOM

Capable to generating and absorbing reactive power the D-STATCOM is a controlled reactive sources. D-STATCOM includes the VSC i.e. voltage sources converter and DC link capacitor connected in parallel or shunt. In practical D-STATCOM there is some losses because of transformer and converter MOSFET/IGBT. These losses take active power from AC lines and difference occur in the VSC voltage and AC voltage. The aim of the D-STATCOM is to control the voltage at a PCC i.e. power point coupling where the lode is connected to the system.
VSC are connected in shunt with a many function ref. paper [7]

1. Voltage regulation
2. Reactive power compensation
3. Eliminations harmonics
4. Power factor correction

There are many method to Extraction of current component. But there is Instantaneous reactive power theory i.e. PQ theory is used. Instantaneous reactive Power theory is based on reactive and real power in time domain. It is also valid for steady state and transient operation.

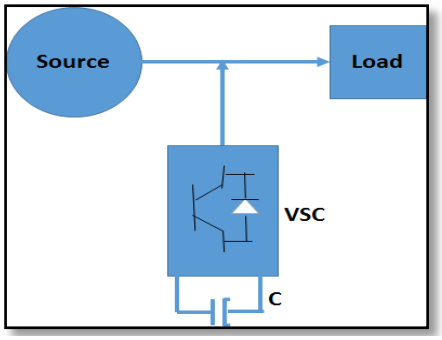

Fig. 8 Basic D-STATCOM

IV. OVERALL SIMULATION

A. Hybrid system simulation model

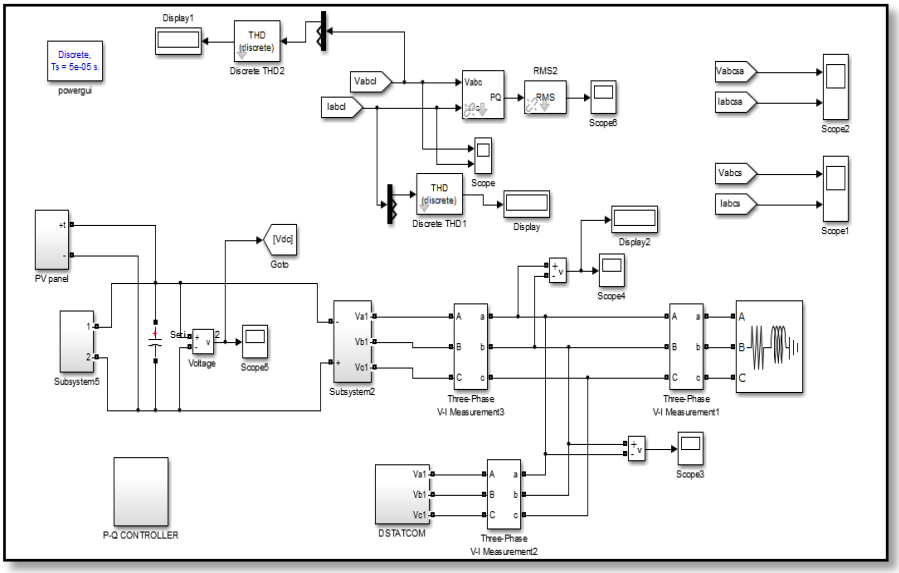

Fig. 9 Overall Simulink model of Wind-PV hybrid system with D-Statcom

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B. Matlab model for PQ Theory

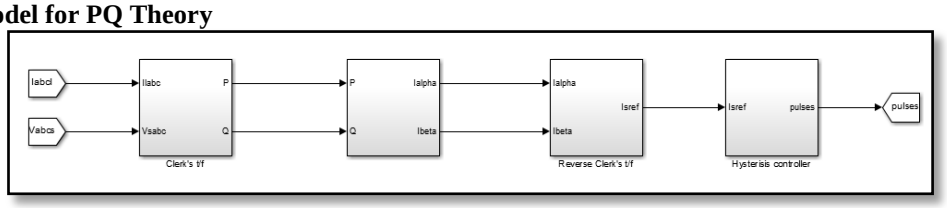

Fig. 10Block diagram for PQ theory

C. Matlab model for hysteresis loss current control

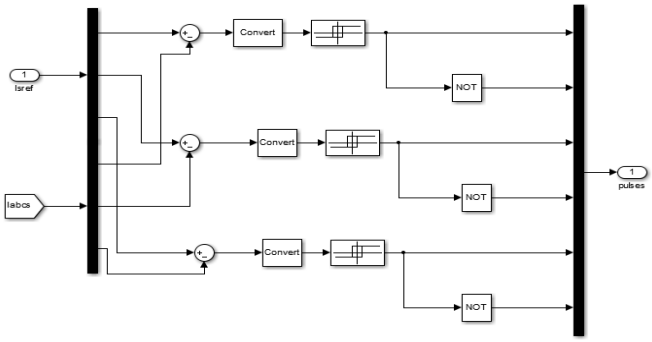

Fig. 11 Hysteresis loss current control

Input data use for hybrid solar, wind power generation system are given in table 1, 2, 3

Table. 1 Parameters of mathematical PV cell

Parameter	**Variable**	**Value**
Current at Maximum Power	*Im*	15 A
Voltage at Maximum Power	Vm	250 V
Open Circuit Voltage	Voc	300 V
Short Circuit Voltage	Isc	20 A
Temperature Coefficient of S.C Current	a	0.015 A/°K
Temperature Coefficient of O.C Voltage	b	0.7V/°K
Internal Series Resistance	Rs	2.7 Ω
Reference Solar Radiation	Sref	1000 W/m2
Reference Temperature	Tref	25°C

Table. 2Parameter of Wind model

Wind Turbine model	
Wind speed	9 m/s
Base wind speed	4 m/s
Pitch angle	0
Rated power	20e3 W
Base generator speed	0.5pu
Generator speed	1pu
PMSG model	
Stator resistance	0.2 Ω
Armature Inductance	0.00015 mH
Pole	5
Rated power	20e3 W

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Table. 3Parameter use in simulation

Load	16e3 W,0.8 pf,50 Hz,400 V
DC-DC boost converter	C=1e-3 F L= 0.005 H
DC link capacitor	20e-3 F
Transformer	20e3 W , 50 Hz Winding 1=100 V Winding 2=250 V Rm=Lm=200

V.RESULT WITH DISCUSSION

Output Power of wind take more time to constant than the hybrid Wind-PV. The settling time for wind is 1.2 sec and for hybrid wind PV is to take 0.4-0.6 sec, so hybrid generation of power is more important than the indivisiual one. Power become increase with the help of PV i.e. solar plant. Because when in winter the sun become low and wind high in summer vice-versa. In part A. wind power shown and then in part B. hybrid generation of power without D-STATCOM and at last in part c. hybrid generation of power with D-STATCOM.

A. Wind generation system

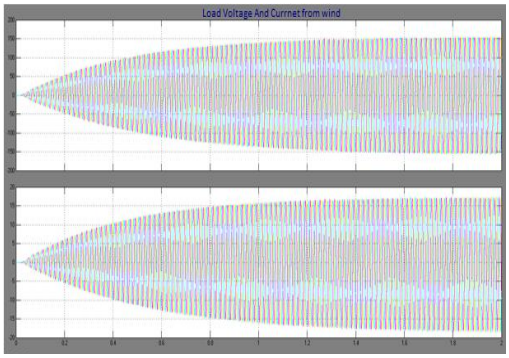

Fig.12Load voltage and current from wind system

In the fig. 12, it shows the graph of load voltage and current from wind system. Because of generator is use in wind system take more time to start,so settling time increase. To reduce that settling time PV system or Battery is use.

B. Hybrid Wind-PV generation system

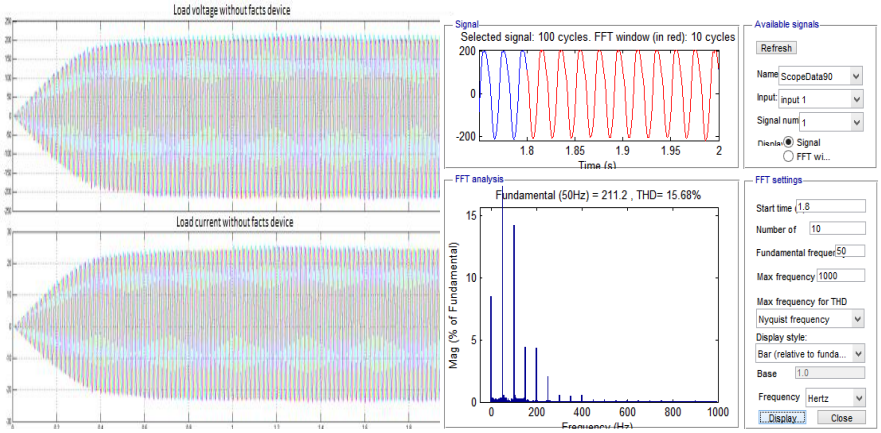

Fig. 13Load voltage and current THDof hybrid systemwithout D-Statcom

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In the fig. 13, it shows that the graph of hybrid system wind-PV. Because of PV hybrid power increases than indivisiual wind system. Harmonics present in the system because hybrid system without D-STATCOM i.e. without facts device

C. Hybrid Wind-PV system with D-Statcom

In the fig 14. Shows below, this hybrid system wind-PV with D-STATCOM. To reduce harmonics present in the system some facts device is used. For variable generation of power, D-STATCOM is useful device to reduce harmonics and maintain power in both side.

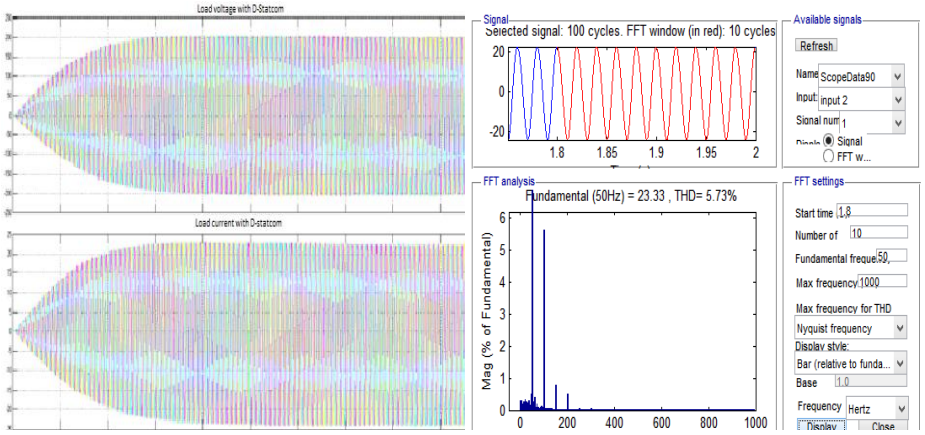

Fig. 14Load voltage, current, current THDof hybrid system with D-Statcom

VI.CONCLUSION

To improvement power quality of the hybrid system it needs the study of all controllers and facts devices. In this work, a fast and cost effective D-Statcom is proposed for reducing the problems of harmonics and maintain AC voltage at both side in distribution system. The result of the simulation are shown with and without D-Statcom. Hysteresis loss current control used to find the error signals which is the difference between the reference current and the load current to trigger the switches of an inverter using PWM (pulse width modulation). The D-Statcom use in the distribution system without any difficulties and injected voltage component to correct the supply voltage by keeping the load voltage constant. In this study, the D-Statcom is reduced the ability of harmonics in the system, total harmonics reduction has been proved by implementation of simulation. The D-Statcom using the PQ theory with Hysteresis loss current control with RL load. Through analysis and simulation, it is shown that the proposed system is more compressive than the other conventional controller. According to IEEE standards THD should be less than the 10%. With using D-Statcom in distribution side the THD are reduced up to 5.73%.

REFERENCES

[1] Dr. T. Govindaraj and Mr. K. Bharanidharan, "Stability and Reliability Improvement in Solar Wind Hybrid Power System with Battery Energy Storage Station," International journal of emerging trend in electrical and electronics, vol. 10, no. 3, pp.49-57, April 2014.
[2] Ahmed M. Atallah, Almoataz Y. Abdelaziz, and Raihan S. Jumaah," Implementation of perturb and Observe mppt of pv system with direct Control method using buck and buck boost Converters," Emerging trend in Electrical and Instrumentation Engineering:An international journal,vol. 1, no. 1, pp.31-45, Feb. 2014.
[3] Prerna Badoni, S. Bhanu Prakash," Modeling and Simulation of 2 MW PMSG Wind Energy Conversion Systems,"IOSR Journal of Electrical and Electronics Engineering,vol. 9, no. 7, pp.53-58, Jul-Aug. 2014
[4] Gilbert M. Masters, Renewable and Efficient Electric Power Systems, A JOHN WILEY & SONS, INC., PUBLICATION, Canada, 2004.
[5] Rajesh Kumar Ahuja, Amit Kumar,"Analysis, Design and Control of Sinusoidal PWM Three Phase Voltage Source Inverter Feeding Balanced Loads at Different Carrier Frequencies Using MATLAB," International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering, vol. 3, no. 5, pp.9557-9963, May 2014.
[6] S.Angalaeswari, M.G.Thejeswar, R.SanthanaPoongodi, W.ValeedBasha, P.Sasikumar,"Power Quality Improvement of Standalone Hybrid Solar-Wind Power Generation System using FACTS Devices," vol. 3, no. 3, pp. 7987-7992, mar. 2014.
[7] TejasZaveri, B.R.Bhalja and NamishZaveri,"Simulation and Analysis of Control Strategies for D-STATCOM," ACEEE International Journal on Control System and Instrumentation, vol. 1, no. 1, pp. 52-56, July 2010.